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(71) Applicant: HONDA GIKEN KOGYO KABUSHIKI KAISHA
Minato-ku, Tokyo (JP)

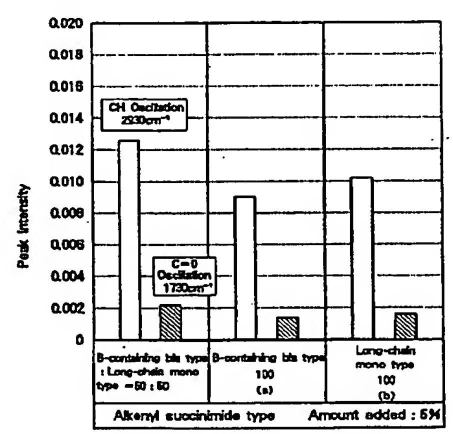
(72) Inventors:
- Okanobori, Hitoshi
  c/o Honda R&D Co., Ltd.
  Saitama-ken (JP)
- Tsuji, Makoto
  c/o Honda R&D Co., Ltd.
  Saitama-ken (JP)
- Ogasa, Hiroshi
  c/o Honda R&D Co., Ltd.
  Saitama-ken (JP)

(74) Representative: Hering, Hartmut, Dipl.-Ing.
Patentanwälte
Berendt, Leyh & Hering
Innere Wiener Strasse 20
D-81667 München (DE)

## (54) Lubricant composition

(57) A lubricant composition comprising two types of alkenyl succinimide, the bis type and the mono type, and a low molecular weight polydimethyl siloxane having a kinematic viscosity of 10-100 cSt and a high molecular weight polydimethyl siloxane having a kinematic viscosity of 5,000-20,000 cSt added to a base oil.

Fig. 1

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## Description

Field of the Invention:

This invention relates to a lubricant composition used as a lubricant for automatic transmissions. Description of the Related Art:

It is well known that an ash-free dispersion agent is used in automatic transmission fluid (ATF) for motor vehicles, motor boats, agricultural machines and the like. It is also well known from, for example, Japanese Patent Laid-Open Publication No. 3-39396 that a metallic cleaning agent is added independently or in combination with the dispersion agent to ATF for the purpose of increasing the coefficient of friction ($\mu$).

However, since the ash-free dispersion agent has a relatively higher effect to increase the coefficient of friction than metallic cleaning agents, increase in the coefficient of friction by increasing the adsorption of the ash-free dispersion agent is considered for a higher coefficient of friction than that of existing ATFs. However, increase in the amount of the ash-free dispersion agent impairs the balance with other additives in the ATF system, resulting in an unstable ATF.

Thus, the addition of an ash-free dispersion agent, friction modifier (FM) or metallic cleaning agent does not achieve a significant increase in the coefficient of statical friction ($\mu$s) and the coefficient of dynamical friction ($\mu$d) and hence is ineffective for torque capacity increase and the size and weight reduction of transmissions by reducing a clutch diameter and decreasing the number of clutches. Also, forced increase in the coefficient of friction by increasing the amount of the ash-free dispersion agent may cause ATFs to become unstable.

On the other hand, some additives having succinimide skeletons have an average molecular weight of 5,500 or more. For example, the lubricant composition disclosed in Japanese Patent Laid-Open Publication No. 6-240275 contains 0.01-3.0 percent by weight of an amine compound, 0.05-5.0 percent by weight of perbasic calcium phenate, 0.5-5.0 percent by weight of a succinimide-based ash-free dispersion agent, and 0.5-5.0 percent by weight of a B-shield type succinimide-based ash-free dispersion agent. The succinimide used has a carbon number on 500-5,000 (molecular weight: 7,000-70,000).

However, when succinimide having molecular weights between 7,000 and 70,000 is added to the base oil having a kinematic viscosity at 100°C of 3 cSt or more an a dispersion agent, the addition of these additives in the same amount as the dispersion agent having a relatively low molecular weight will increase the viscosity of the ATF as a whole. If the amount of the viscosity index improving agent (polymethacrylate) for decreasing the viscosity of the ATF, the desired viscosity index of the ATF may not be achieved.

If the viscosity index of an ATF cannot be kept high, viscosity changes due to temperature change, and if the kinematic viscosity at a high temperature (e.g., 100°C) is kept constant (normally about 7 cSt), viscosity at a low temperature increases.

In this case, the control of the hydraulic pressure of the transmission will become more difficult than in ATFs having a high coefficient of friction and a high viscosity index.

The breakpoint of the viscosity index (VI) at which such difficulty appears is around VI = 190 in the case of the ATF having a high coefficient of friction according to the present invention. That is, the VI of 200 or more is a favorable VI, and the VI less than 190 is unfavorable in the case of ATFs having a high coefficient of friction.

Therefore, it is the object of the present invention to provide a lubricant composition for improving adsorption per unit area, and for improving the coefficient of friction and the viscosity index, by the combination of succinimide.

The inventors of the present invention noticed types inherent to ash-free dispersion agents (8 types described below) without changing the amount, and improved adsorption amount by combining these types to achieve the improvement of the coefficient of friction of the ATF.

It is necessary that alkenyl succinimide used here as an ash-free dispersion agent has alkenyl groups having short chains of an average molecular weight of 1,000-1,500, and long chains of an average molecular weight of 2,000-2,500.

According to the present invention, since no metallic cleaning agent is contained, the adsorption of succinimide is not impaired, and the coefficient of friction ($\mu$) is improved.

The amount of the added friction modifier (FM, alkylamine) is 0.1-1.0. If this amount is smaller than 0.1 percent by weight, $\mu_o/\mu_d$ becomes more than 1, and if this amount is larger than 1.0 percent by weight, the coefficient of friction ($\mu$) tends to decrease.

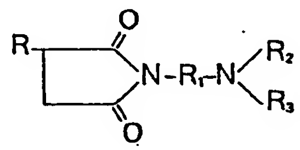
Furthermore, although the viscosity index is improved when a base oil of a low viscosity is used, it is not practical because of volatility.

Alkenyl succinimide used in the lubricant composition as an ash-free dispersing agent includes the following types:

I) Mono type
II) Bis type (two succinimide skeletons)
III) B type (boron introduced type)
IV) Non-B type
V) Long chain type (the average molecular weight of an alkenyl chain is 2,000-2,500)

VI) Non long chain type (the average molecular weight of an alkenyl chain is 1,000-1,500).

The chemical formulas of I) to VI) are as follows:



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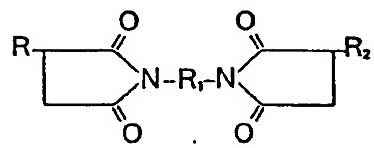

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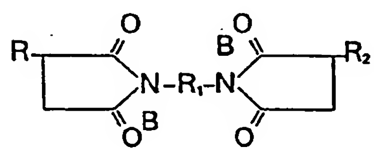

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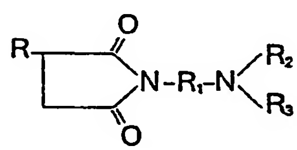


···· I)、IV)、V)

(Note): $R_1$, $R_2$ and $R_3$ represent H, alkyl or alkenyl groups, and R represents an alkenyl group. The bonding of B (boron) is not specified.

The types of alkenyl succinimide are the following eight types including (a) the B containing bis type and (b) the long chain mono type:

(a) B-containing bis type
(b) Long chain mono type
(c) Non-long chain, non-B type
(d) Non-B mono type
(e) Long chain bis type
(f) B-containing mono type
(g) Long chain B containing bis type
(h) Long chain B containing mono type

The combinations of these eight types are as follows:
Combination of two of the eight types: ${}_8C_2 = 28$
Combination of three of the eight types: ${}_8C_3 = 56$
It has been known that the combination of four types or more is ineffective.
In these 28 + 56 = 86 combinations, the combining ratio of the components may be further changed.

As an example of combination, in the combination of (a) B-containing bis type and (b) long-chain mono type, adsorption amount is limited in the cases of only small molecules of (a) and only long-chain molecules (large molecules) of (b). When the combination of 20-80 percent by volume of (a) and 80-20 percent by volume of (b), preferably 40-60 percent by volume of (a) and 60-40 percent by volume of (b) is added to a base oil (mineral oil or synthetic oil), the following effects were found compared with the cases where these types were added individually as shown in the test described below.

(1) Adsorption to iron increases.

As a result,

(2) A high coefficient of friction (μ) is achieved when formulated as an ATF.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing the results of measurements of adsorption;
Fig. 2 is a graph showing the results of the chip-on-disc tests;
Fig. 3 is a graph showing the changes in the coefficients of statical friction due to the changes in the amount of alkenyl succinimide (percent by weight); and
Fig. 4 is a graph showing the changes in the coefficients of dynamical friction due to the changes in the amount of alkenyl succinimide (percent by weight).

Experiments for the measurement of adsorption were performed under the following conditions:

- In a beaker, about 200 ml of a solution prepared by dissolving the additive sample in PAO (poly-α-olefine, 4 cSt at 100°C) to a concentration of 5 percent by weight was taken.
- One side of the SP material (20 mm in diameter, 2 mm in thickness) was ground and buffed to make a mirror surface. This SP material was immersed into the beaker to adsorb the solution at 120°C for 96 hours.
- The sample of the SP material was taken out and its surface was washed with petroleum benzine.
- The peak intensity of the additives adsorbed on the surface of the SP material was measured by IR-RAS (infrared-reflection adsorption spectroscopy).

The average molecular weights of the alkenyl groups in alkenyl succinimide were:

(a) B-containing bis type: 1,000-1,500
(b) Long-chain mono type: 2,000-2,500
(c) Non-B bis type: 1,000-1,500

The molecular weight of the additive having ultra-high molecular weight succinimide skeletons used for comparison was:

(x) Average molecular weight: 5,500-7,000
(y) Average molecular weight: 55,000-70,000

Fig. 1 is a graph showing the results of measurements of adsorption. The abscissa shows (a) B-containing bis type: (b) long-chain mono type = 50%:50%, and (a) B-containing bis type 100% and (b) long-chain mono type 100%, and the ordinate shows the peak intensity. As this graph shows obviously, when alkenyl succinimide was used in the combination of 50 percent (a) B-containing bis type and 50 percent (b) long-chain mono type, adsorption to the SP material (iron) was significantly more than when the above (a) or (b) was used alone.

Fig. 2 is a graph showing the result of the chip-on-disc test. The abscissa shows circumferential velocity (m/s) and the ordinate shows the coefficient of friction (μ). As this graph shows, when the combination of 2.5 percent (a) B-containing bis type and 2.5 percent (b) long-chain mono type, the coefficient of friction was larger than when 5 percent (a) or 5 percent (b) was used alone.

The mono type differs from the bis type in the structure, the number of polar radicals (C=O, N), and molecular weights, and it is considered that by combining them they are easily produce micelles, and that these micelles are adsorbed more densely onto a unit area.

Based on the results of the test, the ATF was adjusted, and the coefficient of statical friction (μs), the coefficient of dynamical friction (μd), and μo/μd were measured using the SAE No. 2 Test. The results are shown in Tables 1, 2 and 3. (The amount of other additives was the same.)

Table 1 shows the results of Examples 1-9, Table 2 shows the results of Comparative Examples 1-10, and Table 3 shows the results of Comparative Examples 8, 11-14 and Examples 10-15. These tests were performed using the SAE No. 2 Test (scratch abrasion test).

TABLE 1

(Unit: wt%)

| Items | | Example 1 | Example 2 | Example 3 | Example 4 | Example 5 | Example 6 | Example 7 | Example 8 | Example 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkenyl succinimide | (a) | 2.5 | 3.0 | 2.0 | 3.5 | 1.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | (b) | 2.5 | 2.0 | 3.0 | 1.5 | 3.5 | 1.25 | 2.5 | 2.5 | 2.5 |
| | (c) | - | - | - | - | - | 1.25 | - | - | - |
| Polymethacrylate | | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Alkyl diphenylamine | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Alkyl amine | | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.2 | 0.1 | 1.0 |
| SP compound | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Polydimethyl siloxane | | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm |
| Base oil (hydrogenated and refined mineral oil) | | Balance | Balance | Balance | Balance | Balance | Balance | Balance | Balance | Balance |
| Kinetic viscosity (cSt) | at 100°C | 7.120 | 7.113 | 7.224 | 7.101 | 7.256 | 7.104 | 7.122 | 7.118 | 7.120 |
| | at 40°C | 31.01 | 31.20 | 31.09 | 31.18 | 30.91 | 30.95 | 31.25 | 31.12 | 31.02 |
| Viscosity index | | 204 | 202 | 209 | 202 | 212 | 204 | 202 | 203 | 204 |
| Low-temperature viscosity (cp) | at -40°C | 6700 | 6800 | 6750 | 6700 | 6800 | 6800 | 6750 | 6700 | 6700 |
| SAE #2 test | $\mu s$ | 0.123 | 0.120 | 0.121 | 0.117 | 0.118 | 0.120 | 0.124 | 0.125 | 0.117 |
| | $\mu d$ | 0.145 | 0.145 | 0.144 | 0.144 | 0.143 | 0.143 | 0.145 | 0.146 | 0.144 |
| | $\mu o/\mu d$ | 0.976 | 0.973 | 0.975 | 0.969 | 0.972 | 0.974 | 0.980 | 0.985 | 0.922 |

The following additives are added to the base oil up to 30 percent. (The addition more than 30 percent has no effect to meet the costs of the additives.)

(Cleaning and dispersing agent)

Alkenyl succinimide: 1-10 percent
No effects are expected by the addition of 1 percent or less; oxidation stability becomes poor, and precipitation is formed by the addition of 10 percent or more.

(Viscosity index modifier)

Polymethacrylate: 4-20 percent
No effects are expected by the addition of 4 percent or less; solubility becomes poor by the addition of 20 percent or more.

(Antioxidant)

Alkyl diphenylamine: 0.5-4 percent
No effects are expected by the addition of 0.5 percent or less; the oil is degraded by the addition of 4 percent or more.

(Friction adjusting agent)

Alkylamine: 0.05-1 percent
No effects are expected by the addition of 0.05 percent or less; the oil is degraded by the addition of 1 percent or more.

(Extreme pressure agent)

SP compound ("VANLUBE 719" marketed by R. T. Banderbilt Company, Inc.): 0.1-4 percent
No effects are expected by the addition of 0.1 percent or less; poisoning becomes high and heat resistance becomes poor by the addition of 4 percent or more.

The kinematic viscosity of the base oil is 3-5 cSt at 100°C. The combination of two or more fractions of mineral oil or synthetic oil may be used. Although a low-viscosity base oil may be used for increasing viscosity index, it cannot be used for a long period because of its high volatility and low flashing point.

The proportions of additives are shown in the description of each Example. Once the amount of an additive is determined, the amount of other additives is determined proportionally, and the lubricant system is balanced.

(Example 1):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The former proportional equation indicates the proportion for the base oil, and the latter indicates the proportion between two types of alkenyl succinimide. This is also applicable to the following examples.

(Example 2):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 3.0 wt%:2.0 wt% = 60 wt%:40 wt% was used.

(Example 3):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.0 wt%:3.0 wt% = 40 wt%:60 wt% was used.

(Example 4):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 3.5 wt%:1.5 wt% = 70 wt%:30 wt% was used.

(Example 5):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 1.5 wt%:3.5 wt% = 30 wt%:70 wt% was used.

(Example 6):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type:(c) non-B type = 2.5 wt%:1.25 wt%:1.25 wt % = 50 wt%:25 wt%:25 wt% was used.

(Example 7):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of alkyl amine for the base oil was 0.2 wt%.

(Example 8):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of alkyl amine for the base oil was 0.1 wt%.

(Example 9):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of alkyl amine for the base oil was 1.0 wt%.

TABLE 2

(Unit: wt%)

| Items | | Compara. Example 1 | Compara. Example 2 | Compara. Example 3 | Compara. Example 4 | Compara. Example 5 | Compara. Example 6 | Compara. Example 7 | Compara. Example 8 | Compara. Example 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkenyl succinimide | (a) | 5.0 | - | 0.5 | 4.5 | 1.0 | 4.0 | (x)2.5 | (x)2.5 | (a)2.5 |
| | (b) | - | 5.0 | 4.5 | 0.5 | 4.0 | 1.0 | (y)2.5 | (y)2.5 | (b)2.5 |
| | (c) | - | - | - | - | - | - | - | - | - |
| Polymethacrylate | | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 4.0 | 8.0 | 8.0 |
| Alkyl diphenylamine | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Alkyl amine | | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.01 |
| SP compound | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Polydimethyl siloxane | | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm | 50ppm |
| Base oil (hydrogenated and refined mineral oil) | | Balance | Balance | Balance | Balance | Balance | Balance | Balance | Balance | Balance |
| Kinetic viscosity (cSt) | at 100°C | 7.007 | 7.303 | 7.290 | 7.044 | 7.282 | 7.081 | 7.122 | 8.044 | 7.119 |
| | at 40°C | 30.71 | 30.87 | 30.88 | 30.72 | 31.06 | 31.02 | 33.89 | 37.62 | 31.02 |
| Viscosity index | | 201 | 215 | 214 | 203 | 212 | 202 | 181 | 195 | 204 |
| Low-temperature viscosity (cp) | at −40°C | 6700 | 6800 | 6800 | 6700 | 6800 | 6750 | 10300 | 10200 | 6700 |
| SAE #2 test | $\mu s$ | 0.110 | 0.113 | 0.113 | 0.112 | 0.114 | 0.113 | 0.119 | 0.120 | 0.127 |
| | $\mu d$ | 0.140 | 0.141 | 0.141 | 0.140 | 0.141 | 0.141 | 0.144 | 0.143 | 0.146 |
| | $\mu o/\mu d$ | 0.968 | 0.971 | 0.970 | 0.969 | 0.970 | 0.969 | 0.985 | 0.981 | 1.033 |

Note: (x) and (y) respectively show the B-containing bis type and the long-chain mono type of ultra-high molecular weight alkenyl succinimide.

In these examples, the amount of polydimethyl siloxane is in the range between 10 and 100 ppm. If the amount is less than 10 ppm, the improvement of the coefficient of friction cannot be expected; if the amount exceeds 100 ppm, no dispersion occurs.

In these examples, the reasons why the coefficient of friction improves and the viscosity index improves are considered that since polydimethyl siloxane makes the arrangement of the bis type and the mono type uniform, adsorption to iron is densified, and adsorption increases. It is also considered that polydimethyl siloxane inhibits the foaming of oil caused by the mechanical agitation of the ATF, and assists the dispersion of the bis and mono types, and adsorption to metals. The above adsorption is considered to be especially promoted when high molecular weight polydimethyl siloxane (kinematic viscosity: 5,000-20,000 cSt at 25°C) and low molecular weight polydimethyl siloxane (kinematic viscosity: 10-100 cSt at 25°C) are mixed in a ratio of 4:1 to 1:4.

In the absence of polydimethyl siloxane, (1) sufficient dispersion and adsorption are not achieved, and (2) defoaming effect is insufficient, the non-contacting area increases due to breaking of oil films, and the improvement of the coefficient of friction of ATF is impaired. For the above reasons, this is considered to have a negative effect on the improvement of the coefficient of friction of ATF.

(Comparative Example 1):

Alkenyl succinimide of (a) B-containing bis type (5 wt%) was used. (b) Long-chain mono type was not used.

(Comparative Example 2):

Alkenyl succinimide of (b) Long-chain mono type (5 wt%) was used. (a) B-containing bis type was not used.

(Comparative Example 3):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 0.5 wt%:4.5 wt% = 10 wt%:90 wt% was used.

(Comparative Example 4):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 4.5 wt%:0.5 wt% = 90 wt%:10 wt% was used.

(Comparative Example 5):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 1.0 wt%:4.0 wt% = 20 wt%:80 wt% was used.

(Comparative Example 6):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 4.0 wt%:1.0 wt% = 80 wt%:20 wt% was used.

(Comparative Example 7):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type:(y) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of polymethacrylate for the base oil was 4.0 wt%.

(Comparative Example 8):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type:(y) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used.

(Comparative Example 9):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of alkyl amine for the base oil was 0.01 wt%.

TABLE 3

(Unit: wt%)

| Items | Ex. 10 | Ex. 11 | Ex. 12 | Ex. 13 | Ex. 14 | Ex. 15 | Comp. Ex. 8 | Comp. Ex. 10 | Comp. Ex. 11 | Comp. Ex. 12 | Comp. Ex. 13 | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkenyl succinimide | (x)2.5 (y)2.5 | (x)2.5 (y)2.5 | (a)2.5 (b)2.5 | (a)2.5 (b)2.5 | (a)2.5 (b)2.5 | (x)2.5 (y)2.5 | (x)2.5 (y)2.5 | (x)5 - | (x)5 - | (a)5 - | (a)5 - | Trilauryl trithiophosphate =SP compound (0.001-1wt%) |
| Polymethacrylate | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | The ratio of low and high molecular weight polydimethyl siloxane: 4:1 to 1:4. |
| Alkyl diphenylamine | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Alkyl amine | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | |
| SP compound | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | The viscosity of low molecular weight polydimethyl siloxane: 10-100 cSt. ≤10 cSt: too low ≥100 cSt: no effect |
| Trilauryl trithiophosphate | 0.01 | 0.01 | - | 0.01 | 0.01 | 0.01 | - | - | 0.01 | - | 0.01 | |
| Polydimethyl siloxane(molecular weight 350cSt) | - | 50ppm | - | 50ppm | - | - | 50ppm | - | 50ppm | - | 50ppm | The viscosity of high molecular weight polydimethyl siloxane is 5,000-20,000 cSt. ≤5,000 cSt: no effect ≥20,000 cSt: no dispersion |
| Polydimethyl siloxane (low molecular weight 50cSt) | 25ppm | - | 25ppm | - | 25ppm | 25ppm | - | 25ppm | - | 25ppm | - | |
| Polydimethyl siloxane (high molecular weight 10,000cSt) | 25ppm | - | 25ppm | - | 25ppm | 25ppm | - | 25ppm | - | 25ppm | - | |
| SAE #2 test μs | 0.121 | 0.123 | 0.124 | 0.125 | 0.125 | 0.123 | 0.120 | 0.114 | 0.117 | 0.110 | 0.110 | |
| μd | 0.145 | 0.145 | 0.146 | 0.146 | 0.146 | 0.146 | 0.143 | 0.140 | 0.143 | 0.140 | 0.139 | |
| μs/μd | 0.983 | 0.984 | 0.979 | 0.985 | 0.987 | 0.988 | 0.981 | 0.973 | 0.978 | 0.968 | 0.967 | |

Note: (x) and (y) respectively show the B-containing bis type and the long-chain mono type of ultra-high molecular weight alkenyl succinimide.

It is considered that when the combination of high and low molecular weight polydimethyl siloxane is used, adsorption caused by the combination of mono and bis types of succinimide was further enhanced, and the coefficient of friction was improved.

It was found that the coefficient of friction is improved when a small amount of trilauryl trithiophosphate is added to ATF together with the combination of mono and bis types of succinimide. It is considered that this further complements the effect of improving the coefficient of friction by the combination of succinimide.

(Example 10):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type:(y) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of trilauryl trithiophosphate for the base oil was 0.01 wt%. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Example 11):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type:(y) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of trilauryl trithiophosphate for the base oil was 0.01 wt%.

(Example 12):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Example 13):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. The proportion of trilauryl trithiophosphate for the base oil was 0.01 wt%.

(Example 14):

Alkenyl succinimide of (a) B-containing bis type:(b) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Example 15):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type:(y) long-chain mono type = 2.5 wt%:2.5 wt% = 50 wt%:50 wt% was used. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Comparative Example 10):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type (5 wt%) was used. (y) Long-chain mono type was not used. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Comparative Example 11):

Ultra-high molecular weight alkenyl succinimide of (x) B-containing bis type (5 wt%) was used. (y) Long-chain mono type was not used. The proportion of trilauryl trithiophosphate for the base oil was 0.01 wt%.

(Comparative Example 12):

Alkenyl succinimide of (a) B-containing bis type (5 wt%) was used. (b) Long-chain mono type was not used. Low and high molecular weight polydimethyl siloxane in an amount of 25 ppm each was added.

(Comparative Example 13):

Alkenyl succinimide of (a) B-containing bis type (5 wt%) was used. (b) Long-chain mono type was not used. The proportion of trilauryl trithiophosphate for the base oil was 0.01 wt%.

Fig. 3 is a graph showing change in the coefficient of statical friction due to change in the amount of alkenyl succinimide shown in Tables 1 and 2, and Fig. 4 is a graph showing change in the coefficient of dynamical friction due to change in the amount (wt %) of alkenyl succinimide.

As Figs. 3 and 4 show, the adsorption of alkenyl succinimide effects increase in $\mu$, and practically high coefficient of statical friction ($\mu s$) and coefficient of dynamical friction ($\mu d$) are obtained when (a) B-containing bis type and (b) long-chain mono type of alkenyl succinimide is added in a proportion of 20-80 percent by weight, preferably 30-70 percent by weight.

In this time, as described referring to Figs. 1 and 2, the average molecular weight of (a) B-containing bis type is about 1,000-1,1500, and the average molecular weight of (b) long-chain mono type is about 2,000-2,500.

ADVANTAGES

The present invention has the following advantages.

By adding an additive comprising two types of alkenyl succinimide, bis type and mono type, a low molecular weight polydimethyl siloxane having a kinematic viscosity of 10-100 cSt and a high molecular weight polydimethyl siloxane having a kinematic viscosity of 5,000-20,000 cSt to a base oil, as defined in Claim 1, the amount of adsorption may be controlled, and the coefficient of friction may be improved.

Similarly, by adding an additive comprising two types of alkenyl succinimide, bis type and mono type, and trilauryl trithiophosphate to a base oil, as defined in Claim 2, the coefficient of statical friction and the coefficient of dynamical friction may be improved.

By adding an additive comprising two types of alkenyl succinimide having alkenyl groups of an average molecular weight of 1,000-1,500 and 2,000-2,500 to a base oil, as defined in Claim 3, the coefficient of friction may be improved.

As defined in Claim 4, by adding an additive comprising two types of alkenyl succinimide having alkenyl groups of an average molecular weight of 1,000-1,500 and 2,000-2,500 to a base oil having a kinematic viscosity of 3 cSt at 100°C, the viscosity index may be improved, and the coefficient of statical friction and the coefficient of dynamical friction may be improved.

## Claims

1. A lubricant composition comprising two types of alkenyl succinimide, the bis type and the mono type, and a low molecular weight polydimethyl siloxane having a kinematic viscosity of 10-100 cSt and a high molecular weight polydimethyl siloxane having a kinematic viscosity of 5,000-20,000 cSt added to a base oil.

2. A lubricant composition comprising two types of alkenyl succinimide, the bis type and the mono type, and trilauryl trithiophosphate added to a base oil.

3. A lubricant composition comprising two types of alkenyl succinimide having alkenyl groups of an average molecular weight of 1,000-1,500 and 2,000-2,500 added to a base oil.

4. A lubricant composition comprising two types of alkenyl succinimide having alkenyl groups of an average molecular weight of 1,000-1,500 and 2,000-2,500 added to a base oil having a kinematic viscosity of 3 cSt or more at 100°C.

Fig. 1

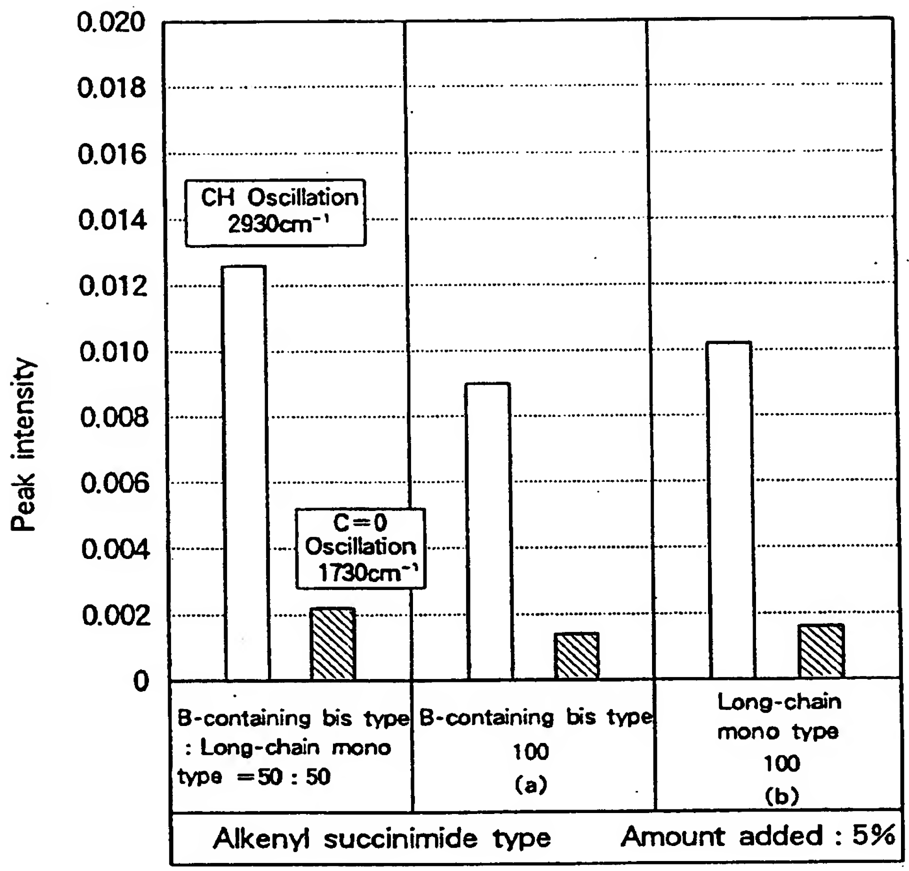

Peak intensity
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0
CH Oscillation 2930cm⁻¹
C=0 Oscillation 1730cm⁻¹
B-containing bis type : Long-chain mono type =50 : 50
B-containing bis type 100 (a)
Long-chain mono type 100 (b)
Alkenyl succinimide type
Amount added : 5%

Fig.2

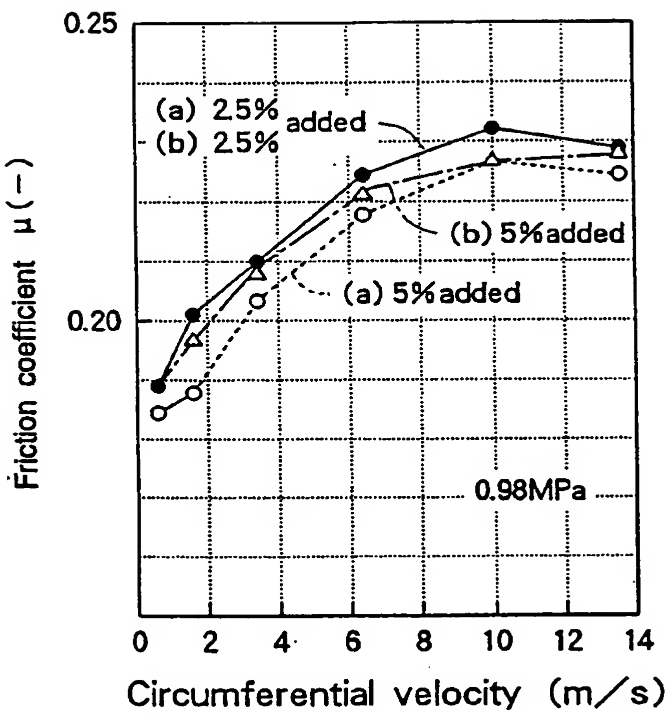

0.25
0.20
(a) 2.5%
(b) 2.5%
added
(b) 5%added
(a) 5%added
0.98MPa
Friction coefficient μ(−)
0
2
4
6
8
10
12
14
Circumferential velocity (m/s)

Fig.3

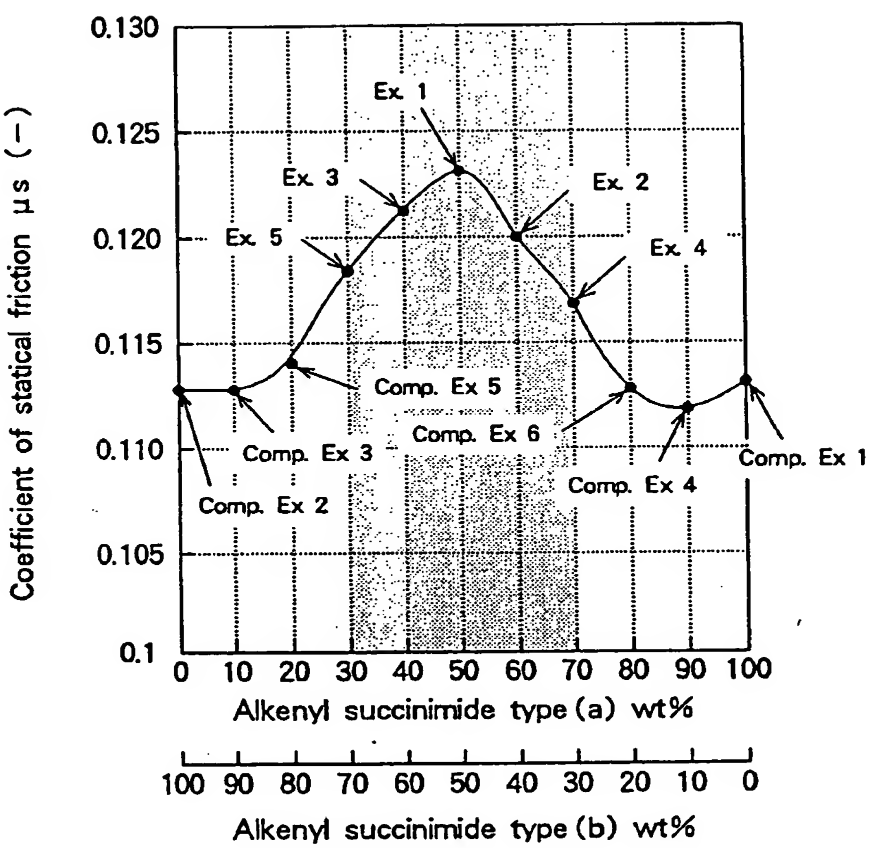
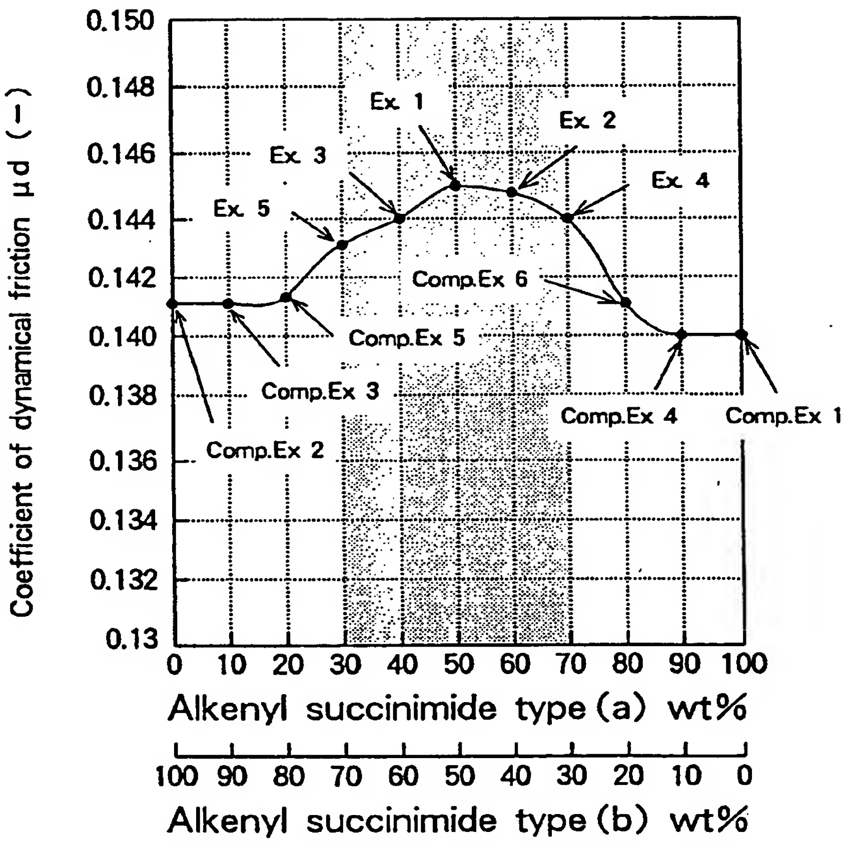

Coefficient of statical friction μs (–)
0.130
0.125
0.120
0.115
0.110
0.105
0.1
Ex. 1
Ex. 2
Ex. 3
Ex. 4
Ex. 5
Comp. Ex 1
Comp. Ex 2
Comp. Ex 3
Comp. Ex 4
Comp. Ex 5
Comp. Ex 6
0 10 20 30 40 50 60 70 80 90 100
Alkenyl succinimide type (a) wt%
100 90 80 70 60 50 40 30 20 10 0
Alkenyl succinimide type (b) wt%

Fig.4


Coefficient of dynamical friction μd (−)
0.150
0.148
0.146
0.144
0.142
0.140
0.138
0.136
0.134
0.132
0.13
Ex. 1
Ex. 2
Ex. 3
Ex. 4
Ex. 5
Comp.Ex 6
Comp.Ex 5
Comp.Ex 3
Comp.Ex 4
Comp.Ex 1
Comp.Ex 2
0 10 20 30 40 50 60 70 80 90 100
Alkenyl succinimide type (a) wt%
100 90 80 70 60 50 40 30 20 10 0
Alkenyl succinimide type (b) wt%

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 95113919.5

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl. 6) |
|---|---|---|---|
| A | DERWENT ACCESSION no. 95-129 180, Questel Telesystems (WPIL) DERWENT PUBLICATIONS, LTD., London; & SU-A-875 842 (BLAGOVIDOV) * Abstract * -- | 1,2 | C 10 M 133/44<br>C 10 M 137/10<br>C 10 M 155/02<br>C 10 M 171/02<br>C 10 M 171/04<br>C 10 M 127/02 |
| A,D | DERWENT ACCESSION no. 94-313 987, Questel Telesystems (WPIL) DERWENT PUBLICATIONS LTD., London; & JP-A-06 240 275 (TONEN CORP.) * Abstract * -- | 1-4 | |
| A | EP - A - 0 113 045 (HONDA MOTOR CO., LTD.) * Claims 1,16 * ---- | 2,4 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.6) |
| | | | C 10 M |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 14-12-1995 | BÖHM |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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